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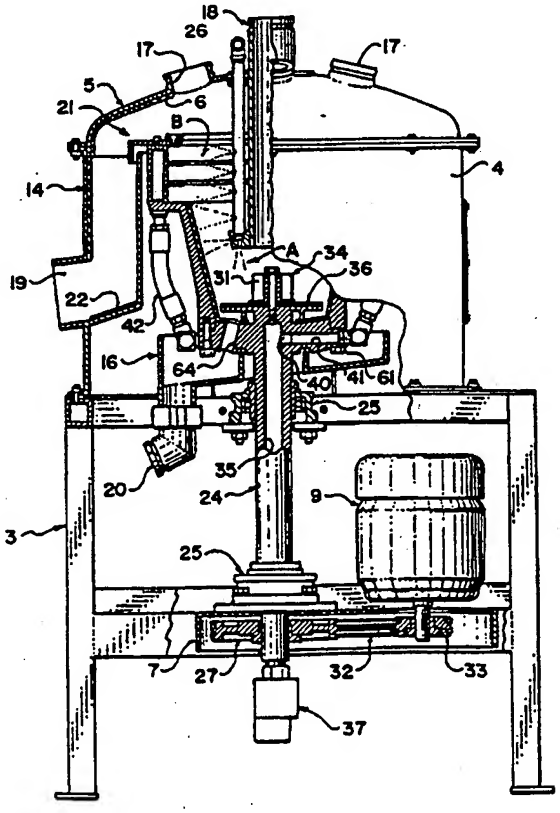
(54) Title: CENTRIFUGAL CONCENTRATOR

(57) Abstract

A centrifugal concentrator for separating higher density particles from a slurry provides reduced water consumption by providing a fluidized capture zone in the upper section of the bowl only, and provides an unobstructed interior migration surface in the lower part of the bowl to provide a preliminary separation of heavier particles.



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# CENTRIFUGAL CONCENTRATOR

The present invention relates to centrifugal concentrators of the rotating bowl type for the separation and recovery of particulate solids of higher specific gravity, such as gold, from a slurry containing such particulate solids as well as particulate solids of a lower specific gravity and liquid.

## BACKGROUND OF THE INVENTION

The problem of separating particles of high density such as precious metals from tailings and other slurry streams has attracted a great many attempted solutions. The problem is that of separating small particles of higher density from a slurry containing water and particles of lower density such as sand. One approach has been to use the centrifugal force created in a rotating bowl to separate the high density particles from the lower density slurry. In the past this had been generally done by placing obstructions such as ribs in the path of the rotating slurry to trap the heavier particles. This method has various problems. Where the slurry contained fine, dense particles such as magnetite, the grooves or depressions designed to retain the concentrate would rapidly pack with the unwanted fine particles.

The problem of packing has been largely solved by the present inventor's centrifugal concentrator which is the subject of U.S. Patent no. 4,824,431 issued April 25, 1989. In that centrifugal concentrator, there are no obstacles to the flow of the slurry in the rotating drum. The slurry is delivered to the vicinity of the bottom of the rotating drum and travels up the smooth interior surface of the drum. The interior surface has three continuous zones: an outwardly inclined migration zone, a generally vertical retention zone above the migration zone, and an inwardly-inclined lip zone above the retention zone. The respective lengths and inclinations of the zones are selected to produce flow conditions in which less dense

particles are expelled from the drum while denser particles migrate to and are retained in the retention zone. The result is that an enriched layer of concentrate accumulates in the retention zone without the use of ridges or grooves which may become packed.

It remains that the above-described centrifugal concentrator is a batch device in which the concentrate retention capacity is quite limited, and so must be frequently stopped to empty it. In some situations, this periodic stoppage can add to the cost and complication of running the centrifuge. Also where the retention zone is flushed frequently the grade of concentrate is low, since a large proportion of non-enriched material is obtained with each flushing of the zone.

A second approach to the packing problem in centrifugal concentrators is that disclosed in Australian Patent no. 22,055/35 (MacNicol), complete specification published 23 April, 1936. Figure 1 of that patent discloses a centrifugal concentrator in which the entire inner wall of the rotating bowl is provided with a plurality of annular riffles and a plurality of orifices arranged at the deepest point between the riffles. Water under pressure is supplied to the orifices through a supply and pressure jacket around the bowl. The flow of liquid through the orifices causes the particles caught in the riffles to be agitated and allows the heavier particles to penetrate to the wall of the bowl.

Centrifugal concentrators of the fluidizing bed approach of Australian Patent no. 22,055/35 have a number of disadvantages. Since a large volume of water is required to supply the water jacket to fluidize the wall of the bowl, concentrators of this type consume a good deal of water. The added water consumption adds to the cost of operation and disposal of the waste slurry output, and in some cases such as grinding circuits can have a negative impact on the overall system. Due to the addition of the fluidizing water to the input slurry, the capacity of the

bowl to process the input slurry is reduced, and more energy is required to rotate the added water required for the fluidization. The addition of internal ridges also adds to the concentrator weight.

There is therefore a need for a centrifugal concentrator which has the advantages of both the McAlister and MacNicol-type centrifugal concentrators, but which uses less water and requires less energy to operate than the MacNicol-type concentrator.

## SUMMARY OF THE INVENTION

The present invention therefore provides a concentrator for separating particulate material of higher specific gravity from a liquid slurry comprising a liquid and particulate material of different specific gravities, the concentrator comprising:

(a) a hollow drum having an open end, a substantially closed end and an inner surface, mounted co-axially on a hollow shaft;

(b) means for rotatably supporting the hollow shaft on an axis;

(c) drive means for rotating the drum and hollow shaft about the axis;

(d) material supply means to deliver the liquid slurry into the end of the drum spaced from the open end;

wherein the inner surface of the hollow drum comprises an outwardly inclined migration surface and a capture zone above the migration surface, wherein the capture zone comprises a generally vertical annular wall located radially outwardly of the migration zone and a flow- obstructing element extending perpendicularly from the vertical wall, and the capture zone is adapted to be fluidized from a source of liquid under pressure located radially outwardly of the capture zone, and the hollow drum further com-

prises a discharge outlet adjacent the closed end.

The present invention further provides a method of separating particulate material of higher specific gravity from a liquid slurry comprising a liquid and particulate material of different specific gravities, the method comprising:

a) providing a concentrator comprising:

(i) a hollow drum having an open end, a substantially closed end and an inner surface, mounted co-axially on a hollow shaft;

(ii) means for rotatably supporting the hollow shaft on an axis;

(iii) drive means for rotating the drum and hollow shaft about the axis;

(iv) material supply means to deliver the liquid slurry into the end of the drum spaced from the open end;

wherein the inner surface of the hollow drum comprises an outwardly inclined migration surface and a capture zone above the migration surface, wherein the capture zone comprises a generally vertical annular wall located radially outwardly of the migration zone and a flow-obstructing element extending perpendicularly from the vertical wall, and the capture zone is adapted to be fluidized from a source of liquid under pressure located radially outwardly of the capture zone, and the hollow drum further comprises a discharge outlet adjacent the closed end; and

v) means for providing liquid under pressure to the capture zone;

b) rotating the hollow drum;

c) feeding the slurry through the material supply means;

d) providing liquid under pressure to provide radially inwardly directed fluidizing liquid in the capture zone to agitate the slurry in the capture zone;

e) stopping the supply of the slurry to the hollow bowl;

f) reducing the speed of the rotation of the bowl and substantially simultaneously providing a reduced volume of fluidizing liquid under pressure to the capture zone; and

g) washing captured particles out of the capture zone through the discharge outlet.

## BRIEF DESCRIPTION OF THE DRAWINGS

In drawings which illustrate a preferred embodiment of the invention:

Fig. 1 is a front perspective view of the centrifuge of the invention;

Fig. 2 is a rear elevation view of the invention, with the shroud and frame partially cut away to illustrate the plumbing assembly;

Fig. 3 is a front elevation view of the invention, partially cut away and partially in section, to illustrate the rotor bowl assembly of the invention;

Fig. 4 is a vertical cross-section of the invention taken along lines 4-4 of Fig.1 with the drive assembly removed and the flushing manifold slightly repositioned for ease of illustration;

Fig. 5 is a detail view taken along lines 5-5 of Fig.2;

Fig. 6 is a detail view taken along lines 6-6 of Fig.5;

Fig. 7 is a detail view showing a section of the rotor bowl in cross-section;

Fig. 8 is a perspective view of the capture zone of the invention, shown in Figure 7;

Fig. 9 is an elevation of the rotor of the invention, partially cut away; and

Fig. 10 is a cross-section taken along lines 10-10 of figure 9 with details of the water supply passages shown in phantom lines.

## DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

With reference to the drawings, the centrifugal concentrator of the invention is designated by reference numeral 1. It has a frame 3, a shroud 4 consisting of shroud lid 5 and tailings launder 14, and drive motor 9. The frame is constructed of hollow steel sections which are sealed to provide water storage, as further described below. The shroud lid 5 has openings for a slurry feed pipe 18 and inspection ports 17 sealed by removable plugs, and an inner lining 6 of a wear resistant material such as LINATEX™ or a natural rubber. The flange of shroud lid 5 is bolted to the upper flange of tailings launder 14. Tailings launder 14 is provided with a tailings discharge port 19 (Fig. 2). A concentrate launder 16 with a concentrate discharge port 20 (Fig. 2) is also provided. The floor 22 of launder 14 (Fig. 3) is sloped downwardly to assist in a smooth outward flow of the discharge and is preferably coated with an ultra-high molecular weight polyethylene or other low friction, wear-resistant material.

Rotor 21 is formed of rotor bowl 23 and hollow rotor shaft 24. The rotor 21 is mounted for rotation in the frame 3 by bearing assemblies 25. The inner surface of rotor bowl 23 forms a migration zone A and a capture zone B (Fig. 3), which cause the denser, target particles from the slurry flow to be concentrated in the capture zone. The rotor shaft 24 has a sheave 27 which is driven by a belt 32 in belt guard 7 driven by electric motor 9 through sheave 33. An impeller 34 is provided on the centre of a baffle 36, which is raised above and secured to the floor of bowl 23. Impeller 34 has a plurality of upstanding vanes 31 to assist in the rotation of the slurry.

An external pipe 26 provides water under pressure

from the frame 3 to a hollow flushing manifold 28 (Fig. 4, 7) secured to feed pipe 18 and provided with holes 29. A plumbing assembly 31 (Fig. 2), described in more detail below, supplies water under pressure to a rotating union 37 through which the water passes to the hollow interior 35 of rotor shaft 24 from where it passes through one of four holes 40 into one of four radially extending passages 41 and thence into one of the four supply hoses 42 which carry the water under pressure to annular chamber 46.

Rotor bowl 23 is formed of a lower bowl section 60, (Figure 3, 7) which is bolted by bolts 61 to the sloping bowl section 62. Section 60 has four concentrate outlets 64. The inner surface of sections 60, 62 and the upper surface of baffle 36 have a lining 63 of a wear resistant material such as a 1/4-inch layer of LINATEX™ or a natural rubber. Section 60 is fixed to rotor shaft 24.

The capture zone B of the present invention comprises a wall portion 47 and circular ribs 50, 52 upstanding from wall portion 47. Wall portion 47 has a plurality of holes 48 formed therethrough in the areas between ribs. Holes 48 communicate with hollow chamber 46 which in turn is supplied with water under pressure through the supply hoses 42. Preferably there are 6 horizontal rows of 1/16 inch diameter holes countersunk to the interior of chamber 40, two rows between shoulder 65 and rib 52, two between ribs 50 and 52 and two between rib 50 and lip 58. The spacing of the holes varies from top to bottom. In the top two rows, preferably the holes are spaced 3/4 inches from centre to centre in each row. In the middle two rows, preferably the holes are spaced 7/8 inches from centre to centre in each row. In the bottom two rows, preferably the holes are spaced 1 inch from centre to centre in each row.

As shown in Figure 7, preferably rib 52 extends further radially inwardly than rib 50, but less than shoulder 65, and lip 58 extends less radially inwardly than rib 50. Thus the tops of ribs 52, 50 follow generally the

slope of the migration zone A if it were extended. As seen in Figure 7, if the surface of the migration zone is extended as a straight line, the capture zone B takes up about 1/3 of the length of the surface (the "length" of the surface meaning the length of an imaginary straight line drawn on the intersection of a vertical plane trough the axis of rotation and the surface of the migration zone A, extended to lip 58), although it could be expanded to cover as much as 50% of the surface length without losing the benefits of the invention. Circular rim 54 is bolted to the upper edge of rotor bowl 23 at 56, forming lip 58. A second circular rim 60 is bolted to the upper surface of rim 56 by bolts 68 to provide a variable thickness or diameter in the lip area according to the particular slurry which is being processed. The "basket" consisting of cylindrical wall 48 and ribs 50, 52 sits in a groove in shoulder 65 and can be readily removed for cleaning by removing lid 5, and rim 54 by removing bolts 56.

Water is supplied to frame 3 through pipe 70, via water filter 72 having pressure gauges 74. External release valve 76 permits water to be released to clean filter 72. Pipe 71 with pressure gauge 82 supplies water from frame 3 to rotating union 37, via valve 73 which is variably throttled by manual lever 75, or by air-operated pinch valve 77. Pinch valve 77 is automatically shut when the motor 9 slows rotor shaft 24 to the rinse cycle, but water continues to flow through bypass pipe to the rotating union 37 during the rinse cycle. A manual lever and valve 80 permits bypass pipe 79 to be manually shut.

In operation, motor 9 is activated to rotate the rotor shaft 24. The slurry feed is introduced to the spinning rotor through feed pipe 18. Centrifugal forces cause the slurry to climb up the migration zone A on inner surface 63 of the rotor bowl section past capture area B before being expelled past lip 58, into tailings launder 14 and thence out of the machine through discharge port 19. The areas between shoulder 65, ribs 50, 52 and lip 58 are

initially empty prior to introduction of the slurry. They rapidly fill with solids as the slurry is introduced. As the process advances, the heavier particles accumulate in these areas. The flow of water under pressure through holes 48 from chamber 46 causes the particles to be agitated and permits the heavier concentrate to accumulate in the area closest to wall 47. Once there has been a sufficient accumulation of concentrate, the feed slurry is shut off, the rotation of the bowl slows to a very gradual rotation, water is sprayed out through manifold 28 and the concentrate flows around baffle 36, out outlets 64 into concentrate launder 16 from where it is collected.

In order to avoid fine slurry particles penetrating into chamber 46 through holes 48, which would necessitate cleaning of chamber 46, and to assist in emptying the rotor of concentrate when the rotor is slowly rotating in the rinse cycle, water is constantly supplied into chamber 46 under pressure, even during the rinse cycle. During the rinse cycle, while the water supply through the main pipe 71 is automatically shut off, a reduced amount of water continues to flow through bypass 79.

An advantage of the present invention is that the action of the rotor 23 acts as a pump to create water pressure in chamber 46, which permits the device to be operated with reduced pump requirements for the water supply pressure when the rotor is rotating. Since the water must flow radially outwardly through passages 41, it is angularly accelerated by the rotation of bowl 23 and is under increased pressure therefore in chamber 46.

Since a smaller portion of the inner bowl surface is fluidized in the present invention than in MacNicol, less water is consumed. The bowl is also lighter and requires less energy to rotate. The placement of migration zone A prior to the capture zone B allows the heavier particles to migrate closer to the wall of the bowl before entering the capture zone and so a reduced capture zone is made possible.

As will be apparent to those skilled in the art, various modifications and adaptations of the structure above described may be made without departing from the spirit of the invention, the scope of which is to be construed in accordance with the accompanying claims.

I CLAIM:

1. A concentrator for separating particulate material of higher specific gravity from a liquid slurry comprising a liquid and particulate material of different specific gravities, said concentrator comprising:

(a) a hollow drum having an open end, a substantially closed end and an inner surface, mounted co-axially on a hollow shaft;

(b) means for rotatably supporting said hollow shaft on an axis;

(c) drive means for rotating said drum and hollow shaft about said axis;

(d) material supply means to deliver said liquid slurry into the end of said drum spaced from said open end;

wherein said inner surface of said hollow drum comprises an outwardly inclined migration surface and a capture zone above said migration surface, wherein said capture zone comprises a generally vertical annular wall located radially outwardly of said migration zone and a flow-obstructing element extending perpendicularly from said vertical wall, and said capture zone is adapted to be fluidized from a source of liquid under pressure located radially outwardly of the capture zone, and said hollow drum further comprises a discharge outlet adjacent said closed end; and

e) means for providing liquid under pressure to said capture zone.

2. The centrifugal concentrator of claim 1 wherein said hollow drum further comprises an annular liquid supply chamber radially outwardly of said capture zone, and said substantially vertical wall of said capture zone comprises a plurality of apertures therethrough communicating with said liquid supply chamber.

3. The centrifugal concentrator of claim 1 wherein said capture zone covers less than 50% of the length of the inner surface of said hollow drum.

4. The centrifugal concentrator of claim 1 wherein said capture zone covers approximately one-third of the length of the inner surface of said hollow drum.

5. The centrifugal concentrator of claim 1 wherein said capture zone comprises upper and lower annular parallel flow-obstructing ribs extending perpendicularly from said substantially vertical wall.

6. The centrifugal concentrator of claim 5 wherein said substantially vertical wall in said capture zone is provided with a plurality of apertures between said upper and lower parallel flow-obstructing ribs, above said upper rib and below said lower rib.

7. The centrifugal concentrator of claim 1 wherein said hollow drum further comprises an annular liquid supply chamber radially outwardly of said capture zone, and said substantially vertical wall of said capture zone comprises a plurality of apertures therethrough communicating with said liquid supply chamber.

8. The centrifugal concentrator of claim 2 wherein said means for providing liquid under pressure to said capture zone comprise liquid carrying passages communicating between said hollow shaft and said liquid supply chamber.

9. The centrifugal concentrator of claim 8 wherein said means for providing liquid under pressure to said liquid supply chamber comprises a rotating union adapted to provided liquid communication between a liquid supply means and said hollow shaft.

10. The centrifugal concentrator of claim 4 wherein said liquid supply means comprises a first supply line which is adapted to be selectively closed or opened and a secondary supply line which is adapted to supply liquid to said rotating union when said first supply line is closed.

11. A method of separating particulate material of higher specific gravity from a liquid slurry comprising a liquid

and particulate material of different specific gravities, said method comprising:

a) providing a concentrator comprising:

(i) a hollow drum having an open end, a substantially closed end and an inner surface, mounted co-axially on a hollow shaft;

(ii) means for rotatably supporting said hollow shaft on an axis;

(iii) drive means for rotating said drum and hollow shaft about said axis;

(iv) material supply means to deliver said liquid slurry into the end of said drum spaced from said open end;

wherein said inner surface of said hollow drum comprises an outwardly inclined migration surface and a capture zone above said migration surface, wherein said capture zone comprises a generally vertical annular wall located radially outwardly of said migration zone and a flow-obstructing element extending perpendicularly from said vertical wall, and said capture zone is adapted to be fluidized from a source of liquid under pressure located radially outwardly of said capture zone, and said hollow drum further comprises a discharge outlet adjacent said closed end; and

v) means for providing liquid under pressure to said capture zone;

b) rotating said hollow drum;

c) feeding said slurry through said material supply means;

d) providing liquid under pressure to provide radially inwardly directed fluidizing liquid in said capture zone to agitate said slurry in said capture zone;

e) stopping the supply of said slurry to said hollow bowl;

f) reducing the speed of said rotation of said bowl and substantially simultaneously providing a reduced volume of fluidizing liquid under pressure to said capture zone; and

g) washing captured particles out of said capture zone through said discharge outlet.

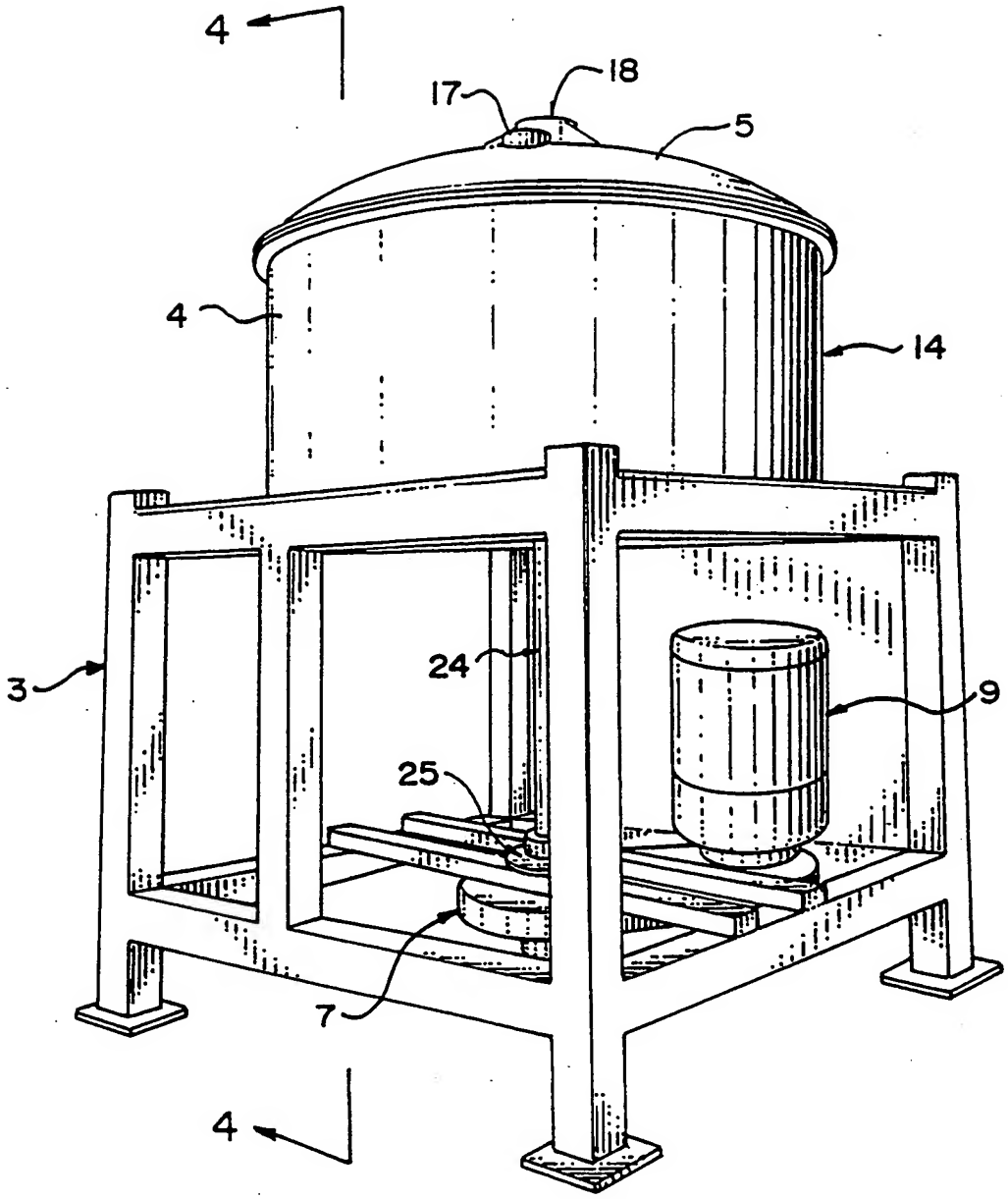


FIG. 1

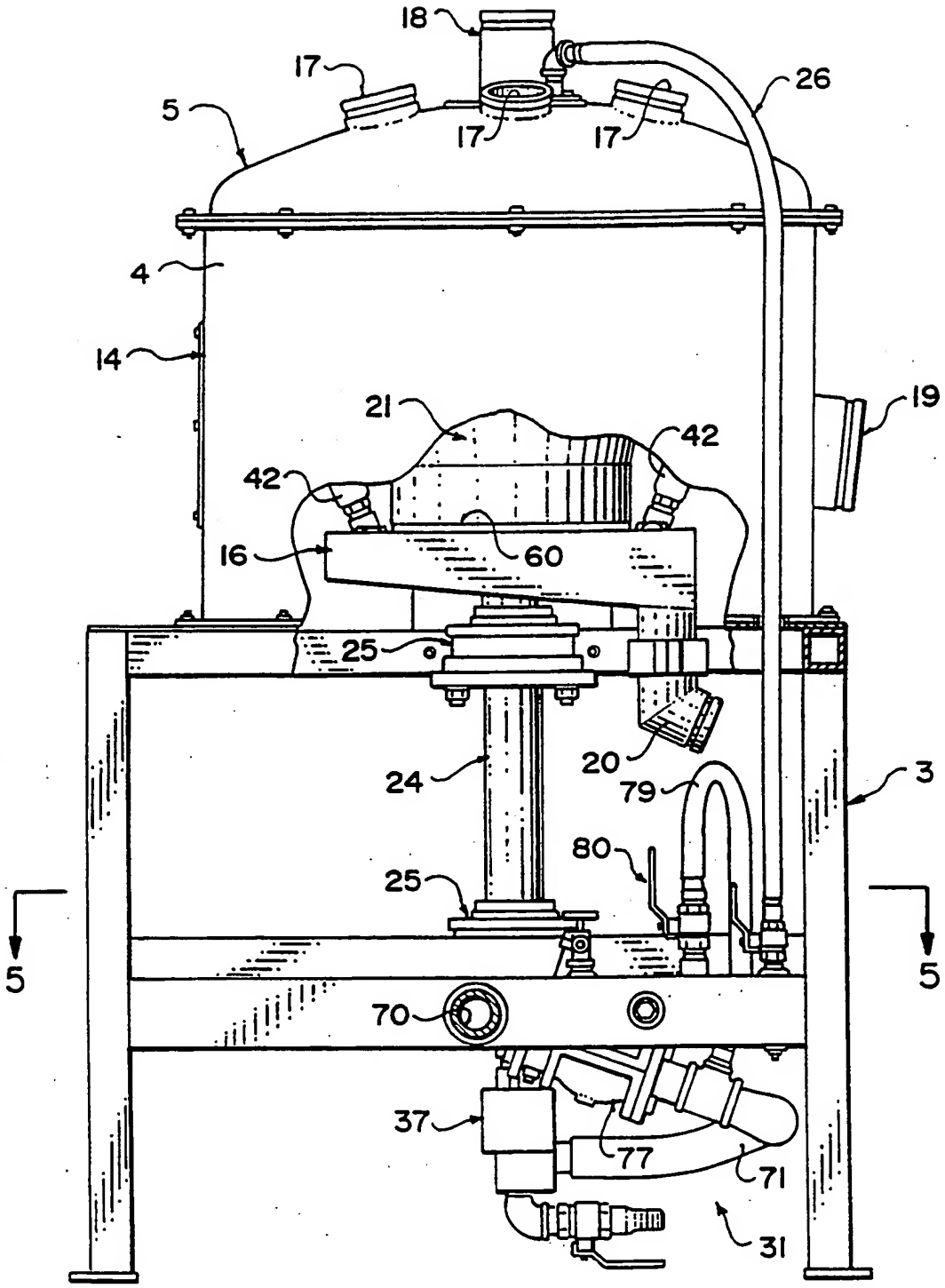
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FIG. 2

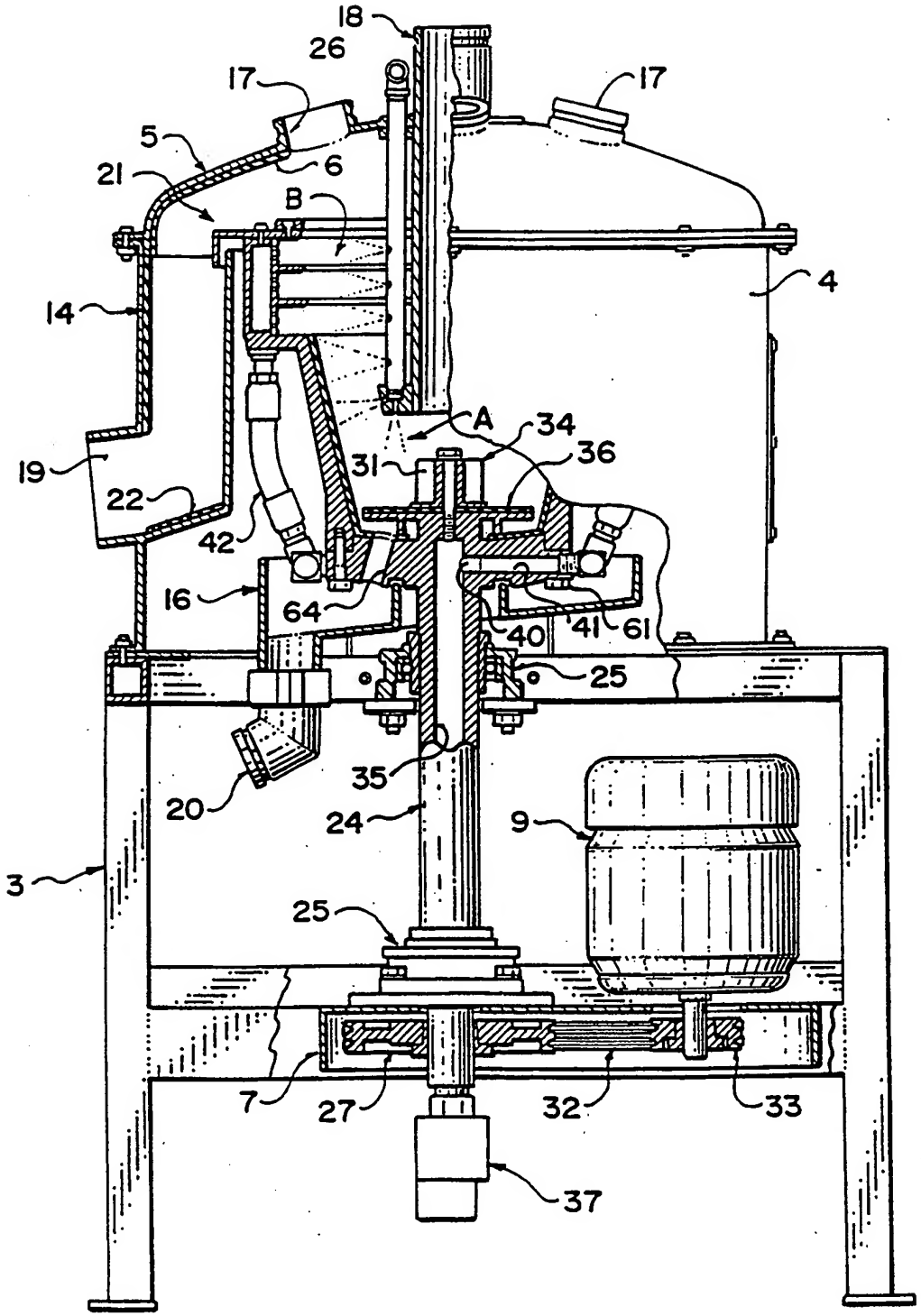
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FIG. 3

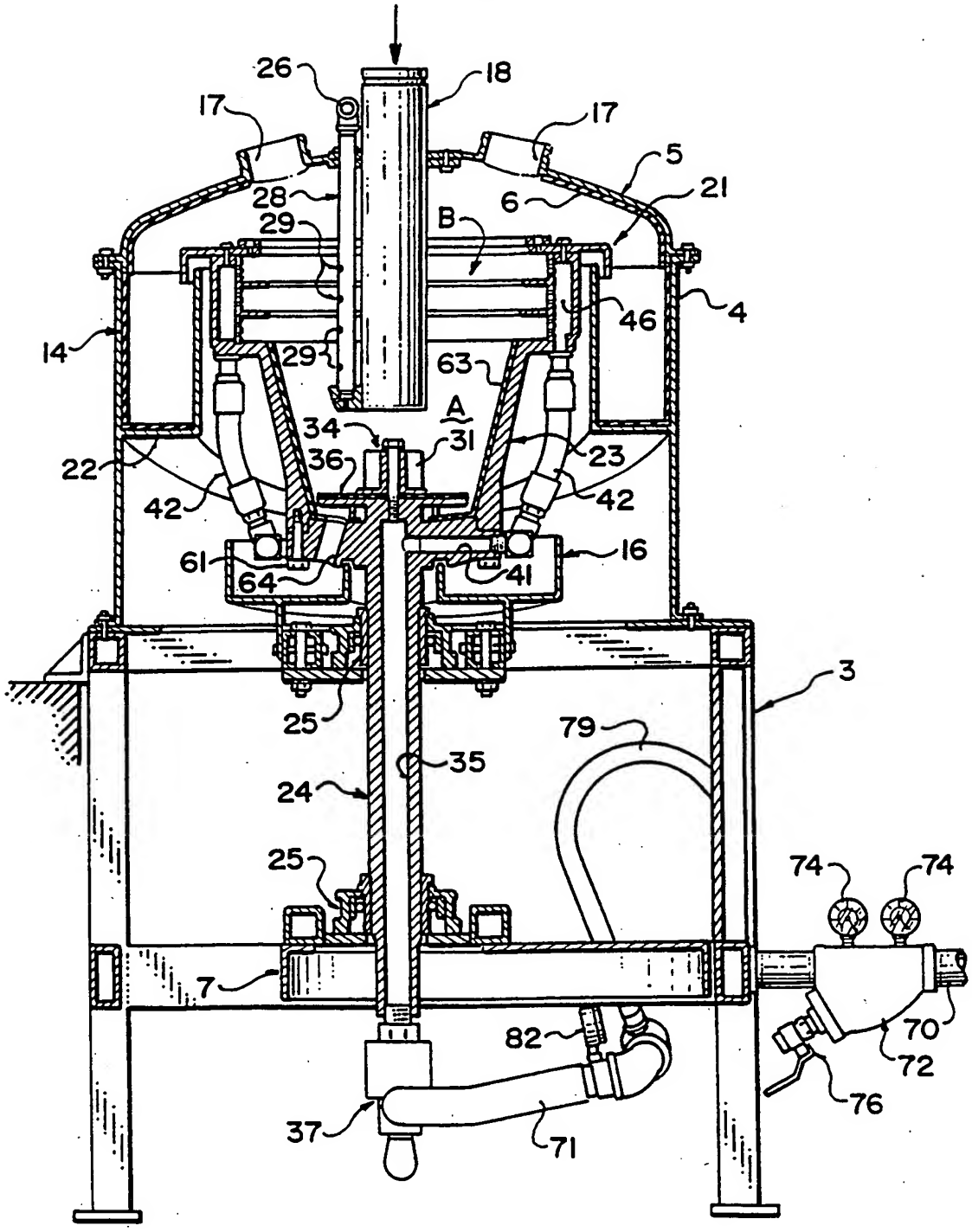
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FIG. 4

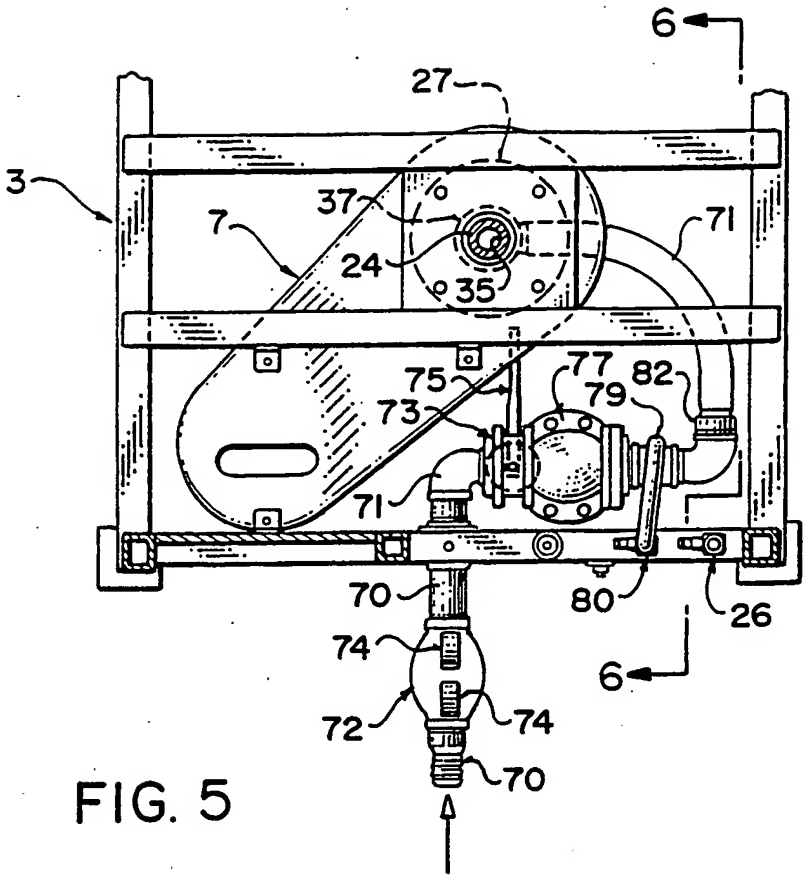
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FIG. 5

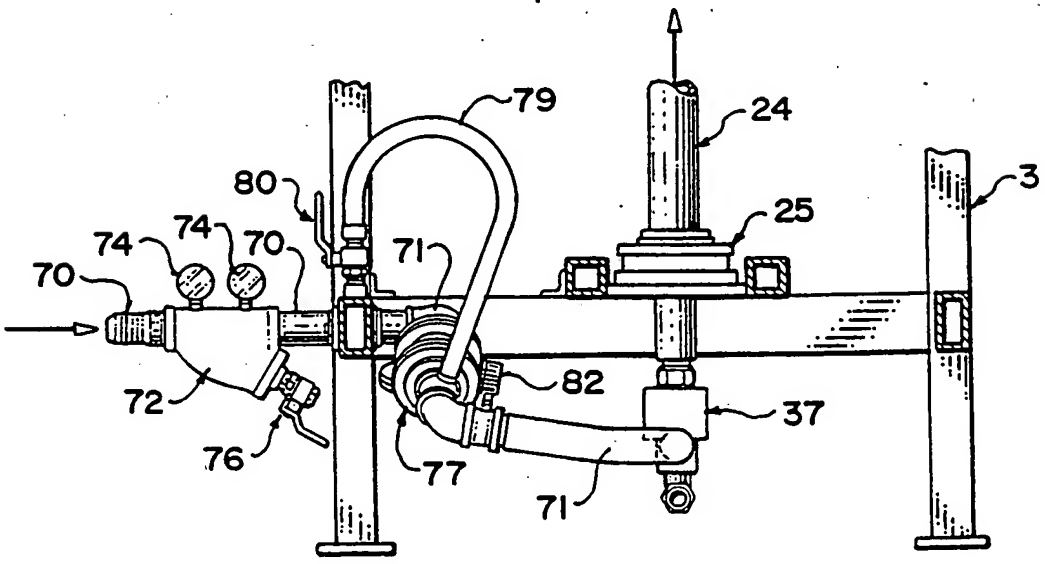
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FIG. 6

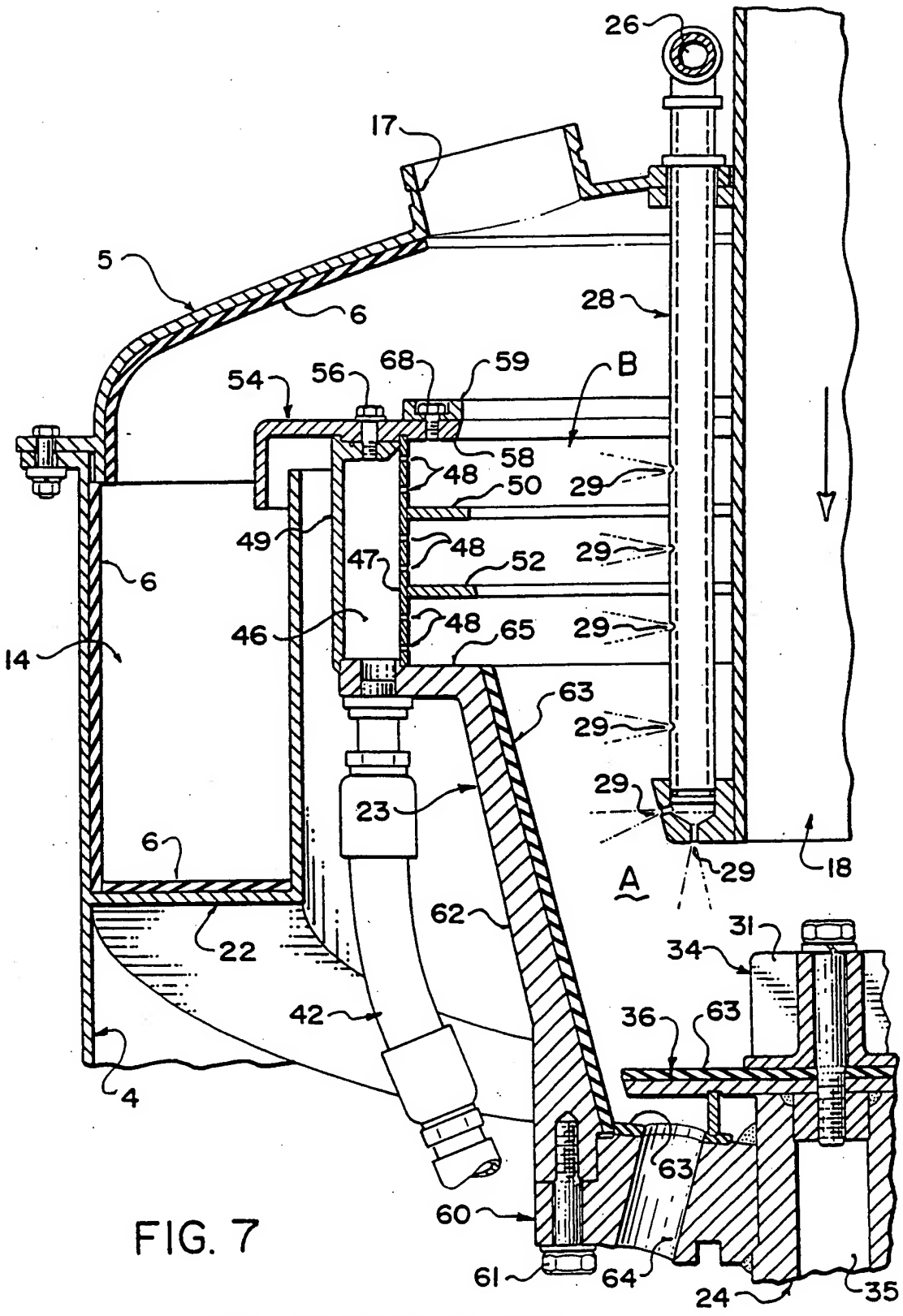
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FIG. 7

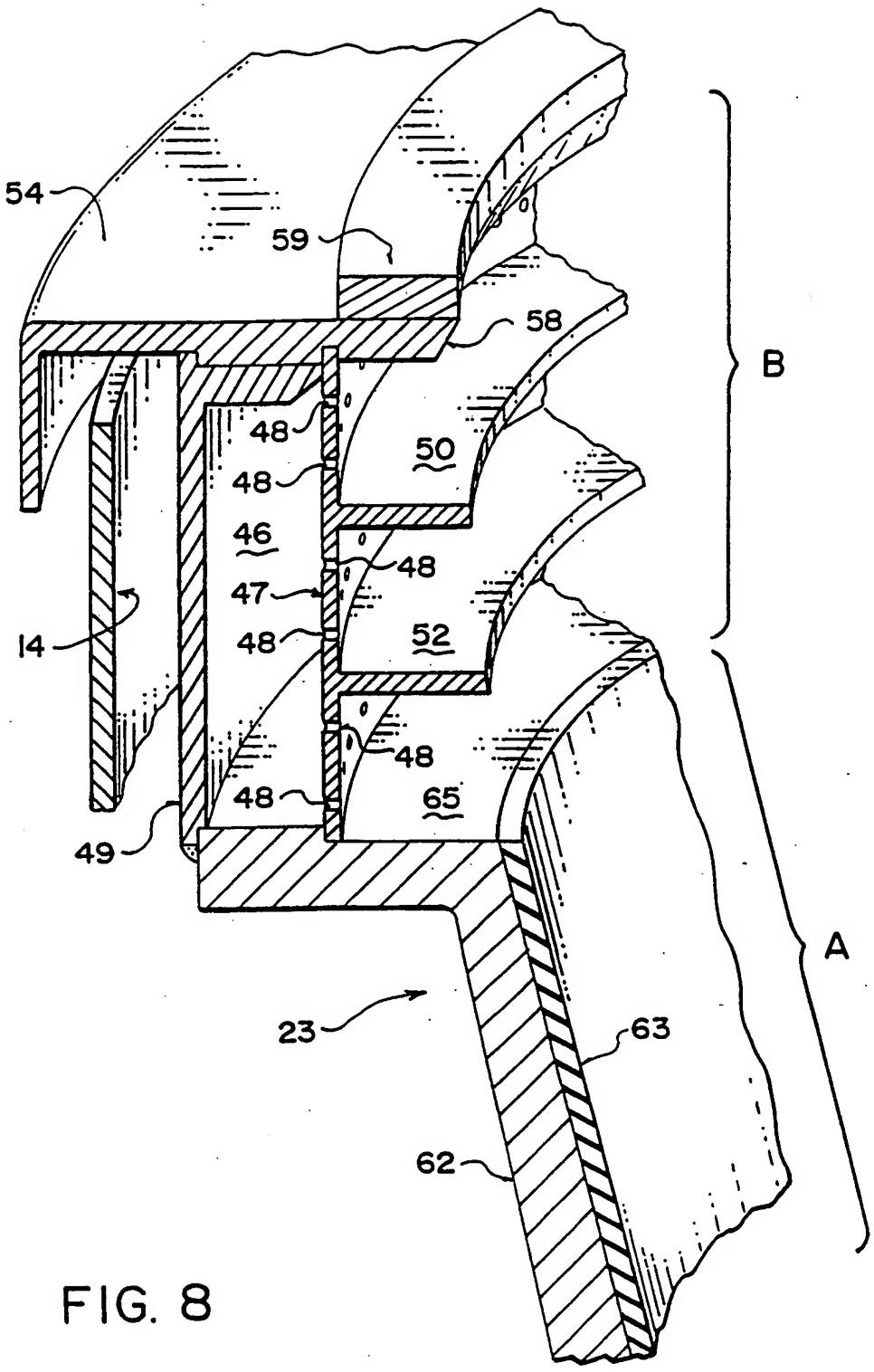


FIG. 8

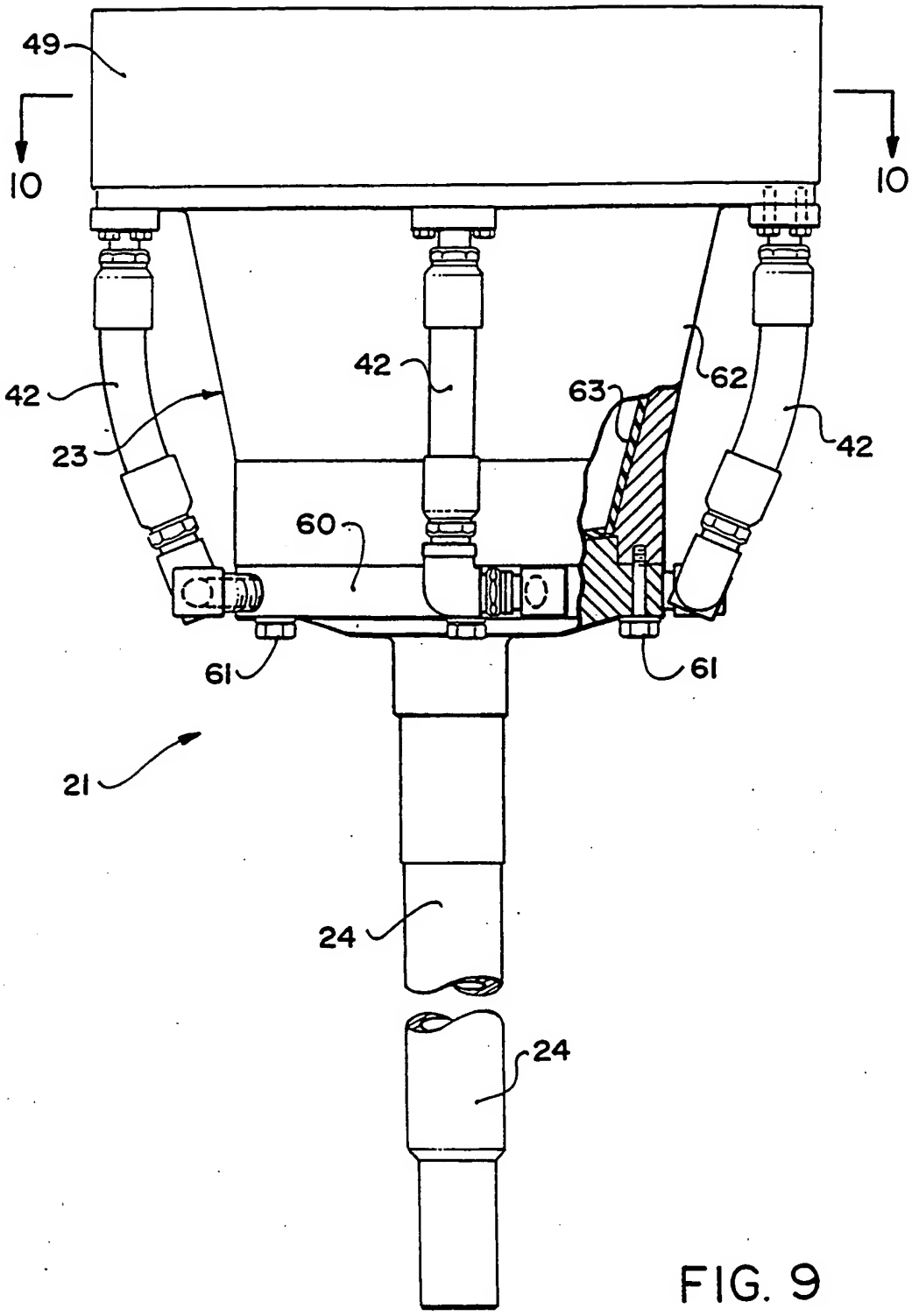


FIG. 9

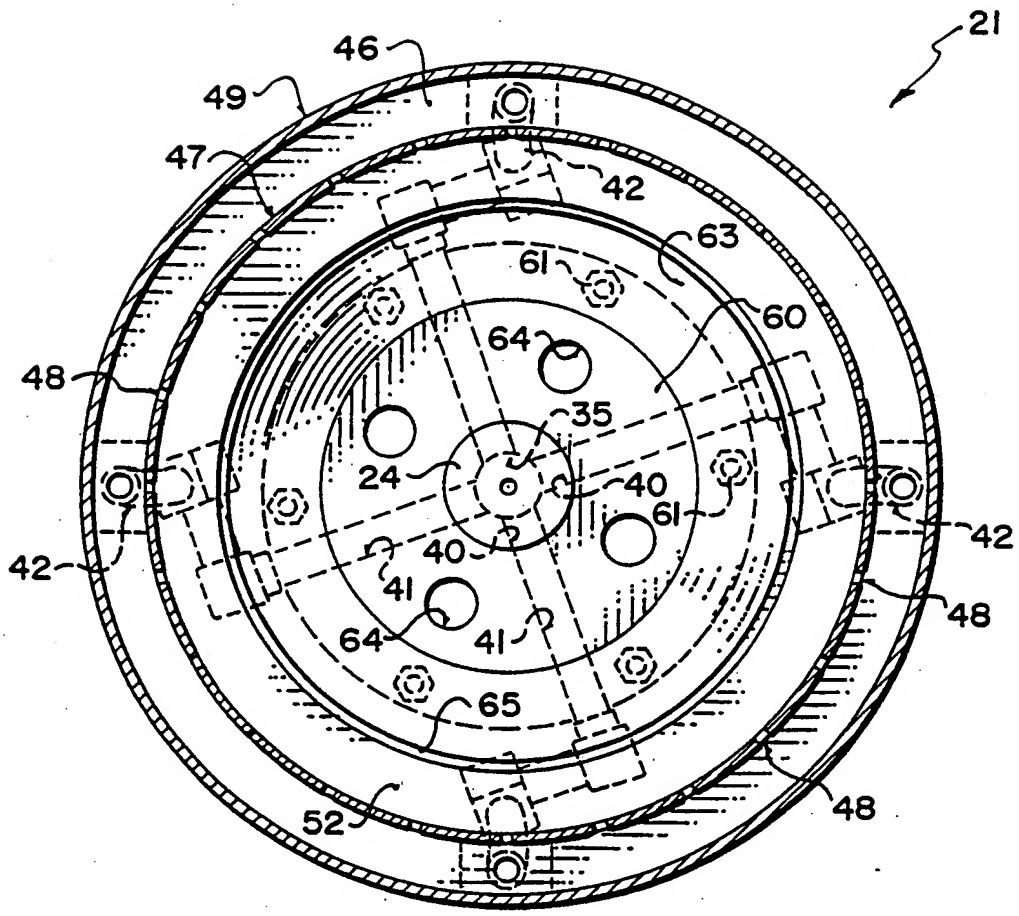


FIG. 10

# INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/CA 96/00338

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B04B1/00 B04B15/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | AU,B,2 205 535 (A.N. MACNICOL) 23 April 1936<br>cited in the application<br>see column 7, line 1 - line 36<br>see figure 1 | 1,11 |
| A | US,A,4 286 748 (A.C. BAILEY) 1 September 1981<br>see abstract; figure 2 | 1,11 |
| A | GB,A,2 133 722 (CLASICON) 1 August 1984<br>see abstract; figure 1 | 1,11 |

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| 24 September 1996 | 26.09.96 |

| Name and mailing address of the ISA | Authorized officer |
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# INTE ATIONAL SEARCH REPORT

Information on patent family members

Inte onal Application No
PCT/CA 96/00338

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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